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Age and Sex Based Multivariate Analysis of Body Morphology Using PCA

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Abstract: Genetic diversity provides the basis for improvement of indigenous goat through selective breeding. Principal component analysis of morphometric traits of the three indigenous breeds of Nigeria goats were carried out based on age and sex. A total of 900 goats were used for the study. Data were collected on BW: Body weight; HL: Horn Length; EL: Ear Length; SW: Shoulder width; NC: Neck circumference; BL: Body Length; WH: Wither Height; HG: Heart Girth; PG: Pouch Girth and TL: Tail Length respectively. Principal component analysis results indicated higher loadings for HG and PG in the PC1 for all classes, while indicating breed specific differences with the Sahel loading for length related indices such as HL, EL and BL (body shape components) a characteristic that is due to its environmental adaptation which has made it the longest and tallest breed best suited for milk but not meat production. Sexual loadings indicated females having better prediction results when body shape components are considered and the males are better judged using body volume measures, however, breed and age interaction must be taken into consideration.
Keywords: Genetic diversity, morphometric traits, component analysis

INTRODUCTION

Relationships between age, body measurements and body weights have been investigated in goats. Ngere [1] carried out a comparative study of the structural variation between red Sokoto goat and WAD goat –based on linear body measurements; it was observed that the relationship existing among linear body traits provide useful information on performance, productivity and carcass characteristics of these farm animals. Besides, body weight and linear body measurements of meat animals have been found useful in quantifying body size[2]. The quantitative measurements for size and shape are necessary for estimating genetic parameters in animal breeding programmes[3]. Fajemilehin and Salako[4] reported that age strongly influenced body weight and body linear traits in West African Dwarf goats, as there were consistent increases in all the traits studied as the animals aged. This scenario is however not surprising, since the size and shape of the animals is expected to increase as the animals are growing with age. Sex is also an important source of variation for body weight and body linear measurements. Several study reported that both sex and strains significantly influenced body weight and linear traits[5-7]. Olutogun *et al*. [8], however, reported a non-significance effect of sex on body weight and linear measurements except heart girth because the animals measured were brought for sale and were probably therefore made to appear robust by feeding them grasses and water ad-libitum before bringing them to market – for sale to attract good prices and because male animals usually have larger gut fill than the females, they then tend to assume false weight. Multifactorial discriminant analysis of morphological characters measured from adequately large sample sizes has been successfully used to estimate overall genetic variation within and between goat populations[9-11].

The aim of this study was to evaluate the effect of age and sex on principal component analysis of morphometric traits in Nigeria goats.

MATERIALS AND METHODS

Experimental Animals and Management.

Animals used for this study were sampled in the abattoir, of Borno, Sokoto and Ogun states when brought for slaughter either by the owner or by the slaughter man. It is believed that all animals find their way into the abattoir from villages and local markets, where they are kept in small numbers by local farmers; they are raised under the extensive system of management.

Sampling Size and Sampling Structure

A total of nine hundred (900) goats comprising of three hundred Sahel goats from Borno state, three hundred Red Sokoto goats from Sokoto state and three hundred West African Dwarf goats from Ogun state were used for the study. Each breed consisted of three hundred goats each, made up of fifty males and fifty females distributed in the following age groups <1, 1-2 and 2-3 years. These were evaluated for morphological,

morphometric and biochemical polymorphism characteristics

Age Determination

The pairs of permanent incisors in the dentition of the goat were used to determine age.

Morphometric Measurements

Reference marks used for body measurement according to the method[9] were :

- Wither Height (WH): Vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones to the fore hoof.
- Body Length (BL): Distance between points of shoulder to point of hip i.e the distance from the first thoracic vertebrae to base of tail. This is also described as the distance between in the most cranial palpable spinosus process of thoracic vertebrae and either sciatic tubers or distance between the tops of the pelvic bone.
- Shoulder width (SW): Measured as the horizontal distance between the two shoulders or distance between the lateral tuberisities of the humeri which is also described as the widest point over the intraspinus muscle.
- Tail Length (TL): Measured from the base of the tail to the tip (Coccygeal vertebrae)
- Neck Circumference (NC): Taken as the circumference of the neck at the midpoint.
- Heart Girth (HG): Measured as the circumference of the body at the narrowest point just behind the shoulder perpendicular to the circumference of the body, just in front of the hind leg perpendicular to the body axis.
- Horn Length (HL): Measured as he average of the lengths of the two horns taken from the base to the tip. Average was used in order to make allowance for unexplained inequalities in horn length.
- Scrotal Circumference (SC): Measured as the circumference of the scrotum taken at the mid-point.
- Ear Length (EL): Measured as the distance from the base to the Zygomatic arch of the ear.

Statistical Analysis

Principal Component Analysis

Principal component analysis of morphometric measures and their contribution to live body weight were evaluated using the Factor Procedure of SAS (1990) for overall pooled data and based on age and sex.

RESULTS AND DISCUSSIONS

Eigenvalues and share of total variance along with factor loadings and communalities of morphometric traits of indigenous breeds of goat based on Age are presented in Table 2. For animals less than a year old, total variance accounted for by Eigenvalue ≥ 1 were 20.58, 20.56 and 19.27%. They were 28.10, 20.46 and 10.54% for goats between 1-2 years old and 28.07, 18.93 and 12.82%for those that were 2-3 years of age.In the first age, EL, HL, SW and TL (dealing with body extremities) was loaded by the first component, none was loaded by the second component, though HG and PG had high (0.99) loadings and BL with WH were accounted for in the third component.WH, HL, BL, EL, SW and TL were accounted for by PC1 in the second age group, PC2 accounted for HG and PG and PC3 for NC thus, indicating a gradual progression away from using the dimensions of extreme body part to using the main torso as a judge of body conformation and size when compared with the first age group.In the third age group, the general body dimensions including the extremities were all accounted for. PC1 loaded WH, SW, BL, HL and EL while PC2 showed that HG and PG contributed 18.93% of total variation observed. The PC3 accounted for NC, TL and EL in its share of total variance.

Table 1:Eigenvalues and share of total variance along with factor loadings and communalities of morphometric traits of Nigerian breeds of goat based on Age

	(<1 year)				**(1 -2years)**				**(2-3 years)**			
Traits	PC1	PC2	PC3	Comm-unality	PC1	PC2	PC3	Comm-unality	PC1	PC2	PC3	Comm-unality
HL	**0.74***	-0.12	0.25	0.62	**0.74***	0.03	0.02	0.55	**0.72***	0.05	0.10	0.53
EL	**0.78***	-0.10	0.03	0.61	**0.67***	0.25	-0.13	0.54	**0.55***	-0.09	**0.51***	0.56
SW	**0.72***	0.06	-0.10	0.54	**0.66***	-0.22	-0.18	0.52	**0.84***	-0.14	-0.03	0.72
NC	0.11	-0.16	0.69	0.52	0.10	-0.04	**0.95***	0.92	0.00	0.31	**0.75***	0.65
BL	0.02	0.10	**0.82***	0.69	**0.70***	0.00	0.15	0.52	**0.74***	0.00	0.18	0.58
WH	0.10	0.16	**0.82***	0.70	**0.78***	0.06	0.17	0.65	**0.85***	-0.16	0.14	0.74
HG	-0.02	0.99	0.05	0.98	0.02	**0.98***	-0.02	0.97	-0.11	**0.93***	0.01	0.87
PG	0.00	0.99	0.02	0.98	0.05	**0.98***	-0.02	0.96	-0.04	**0.91***	-0.03	0.83
TL	**0.60***	0.10	0.14	0.39	**0.50***	0.03	0.20	0.29	0.12	-0.23	**0.65***	0.49
Eigenvalue	23.39	2.10	1.55		2.88	2.02	1.06		3.13	1.79	1.06	
%variance	20.58	20.56	19.27		28.10	20.46	10.54		28.07	18.93	12.82	

HL: Horn Length; EL: Ear Length; SW: Shoulder width; NC: Neck circumference; BL: Body Length; WH: Wither Height; HG: Heart Girth; PG: Pouch Girth and TL: Tail Length.

Table 2: Eigenvalues and share of total variance with factor loadings and communalities of morphometric traits of Nigerian indigenous breed of goat based on Sex.

	FEMALE				**MALE**			
Traits	PC1	PC2	PC3	Communality	PC1	PC2	PC3	Communality
HL	**0.75***	0.05	0.21	0.61	**0.67***	0.07	0.31	0.55
EL	**0.68***	0.19	0.14	0.52	**0.66***	0.09	0.32	0.54
SW	**0.80***	0.05	-0.06	0.64	**0.72***	0.05	0.21	0.57
NC	**0.08***	0.07	**0.93***	0.89	**0.50***	0.23	**0.75***	0.61
BL	**0.60***	0.16	**0.45***	0.59	**0.40***	0.12	**0.71***	0.68
WH	**0.72***	0.16	0.28	0.63	**0.54***	0.07	**0.63***	0.69
HG	0.17	**0.96***	0.08	0.97	0.11	**0.97***	0.18	0.98
PG	0.17	**0.97***	0.06	0.97	0.13	**0.97***	0.16	0.98
TL	**0.53***	0.13	-0.07	0.30	0.73	0.12	-0.09	0.56
Eigenvalue	3.65	1.51	0.95		3.37	1.61	0.83	
%variance	28.92	19.81	12.40		24.17	19.81	17.64	

HL: Horn Length; EL: Ear Length; SW: Shoulder width; NC: Neck circumference; BL: Body Length; WH: Wither Height; HG: Heart Girth; PG: Pouch Girth and TL: Tail Length.

Principal component analysis based on sex across all breeds is presented in Table 1; 28.92% of total variance was accounted for by PC1, 19.81% by PC2 and 12.40% by PC3 in the female goat. The first components gave loadings for SW, HL, WH, EL, BL, TL and NC. While the PC2 retained high loadings for PG and HG, the PC3 accounted for NC and BL. In the male goats, proportion of total variance were 24.17, 19.81 and 17.64 respectively, PC1 had loadings for SW, HL, EL, WH, NC and WH, PC2 had loadings similar to the female goats for PG and HG and PC3 accounted for NC, BL and WH. The consistency of high loading for PG and HG may be termed body shape and depth

By measurement of some body parameters, the age of animals can be assessed and the timing for different management practices can be pegged accurately to bring animals to good and desired weight at maturity[12]. Obtained loadings for animals <1 year and 1-2 years with indications for extremities and height related traits in PC1 may be indicative of rapid growth at this stage this however cannot be associated with the report of Osinowo *et al*., [13] that hearth girth gave best estimate for predicting body weight of Nigerian Red Sokoto goats at 1-2 years of age since HG was loaded for only in PC2 across age 1-2 and 2-3 years only, however, we in part agree with their observation when the loadings of PC2 (0.98) in 1-2 years is compared with 2-3years (0.93) that more of the variation in body weight at age 1-2 years is accounted for by HG than in 2-3years goats where BL and WH were better predictors. Our observation slightly varied from the report of Salako [14] and Mavule *et al*. [13] in sheep were PC1 loaded for traits indicative of body size and PC2 traits indicative of body shape.

The differences in linear body measurements between sexes in different studies were attributed to sexual dimorphism [15, 16]. Baffour-Awuah *et al* [17] observed that females had longer bodies than males and this was also reflected in other measurements such as head length, rump length and tail length, this might account for why BL and WH had higher PC1 (0.60 and 0.72) loadings in the females than the males (0.40 and 0.54) and why TL was loaded in PC1 for the females and not the males. This clearly shows sexual dimorphism in component loadings in Nigerian goats. However, in both sexes, HG and PG were the same and may be a pointer to the supposition that in predicting live weight, length wise traits should be focused on in the females while volume related measures should be employed in the males in addition to HG and PG. Hassan and Ciroma [18]) recommended that sex influence on morphometric characteristics should not be ignored to predict body weight in sheep and goats contrary to the above observations Mahieu *et al*., [19], reported that there was no sex effect on the heart girth to live weight relationship hence there was no need for gender correction. Breed by sex interaction on factor loadings and prediction for BW cannot be overstated.

CONCLUSIONS AND RECOMMENDATIONS

Sexual loadings indicated females having better prediction results when body shape components are considered and the males are better judged using body volume measures, however, breed and age interaction must be taken into consideration.

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